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## (54) CATHODE-RAY TUBE DISPLAY DEVICE


(71) We, PHILIPS ELECTRONIC AND ASSOCIATED INDUSTRIES LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2., a British Company,

do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a projection display device comprising a cathode-ray tube containing an electron gun and a layer, sheet or plate of material which is locally deformable under the influence of an electron beam from said gun, the device also including a light source for directing light to be reflected at said layer.

Such a device will be referred as "of the kind set forth".

With such a device it is possible to project an image on a large screen. If this is done the brightness of the display is determined by the light input to the device which is produced externally to the tube and by the reflectivity of the layer, the electron beam only serving to transfer information to the surface of the layer. This is in contrast to the cathode-ray tubes used in domestic television receivers in which the beam supplies in addition the energy which is eventually emitted by the tube as light so that the light output power of the tube is always lower than the power carried by the electron beam. Because the electron beam must scan a luminescent screen in such a tube and transfer information, the power of the beam cannot be increased sufficiently to give the brightness necessary for projection of the display on a large screen.

One reflection display device of the kind set forth is available under the Registered Trade Mark "Eidophor". In this device light is reflected by a layer present in a cathode-ray tube and the direction in which the light is reflected from the layer is locally varied under the influence of an electron beam. The layer may be a film of oil provided, for example, on a concave mirror. When the film of oil is completely smooth the light is reflected so that no light is passed in the projection direction by an interposed grating (a schlieren optical system). This state of affairs is altered if the film of oil is deformed. A local deformation gives rise to a locally changed reflection direction with the result that the reflected light is passed in the projection direction by the grating and the display is formed. Local deformation of the film of oil is produced by an electric charge the density of which is varied locally. The charge is carried by an electron beam the intensity of which can be varied at a high frequency. A drawback is that an oil film is present inside the cathode-ray tube as a result of which a low but finite pressure of oil vapour is present in the tube. In consequence of this, the life of the tube cathode is restricted so that it has to be replaced regularly. Thus the tube should generally be dismountable and an evacuation system must also be provided.

According to the invention, in a device of the kind set forth the deformable material is electrostrictive or piezo-electric. (Of course it should have a Curie temperature above the operating temperature of the device). Deformation of the layer under the influence of an electron beam may then be made to occur as follows: An electron beam incident upon part of the electrostrictive or piezo-electric material can deposit charge at the surface thereat, as a result of which the layer is deformed. Light from the source is reflected at that part of the layer is reflected at a different angle and, if it was initially stopped by a grating interposed in the direction of projection it may now be passed thereby to form the display.

The layer may be of sintered polycrystalline barium titanate or lead zirconate titanate. If a memory action is desired, the conductivity of the material should be such that the deformation of the layer is maintained for example during a scanning cycle of the electron beam. This can be achieved by adjusting the electric conductivity of the material in the desired manner, for example by reducing or oxidizing the material or by adding dopants.

The relative deformation of the layer increases as the charge is increased. Normally, an intensification of the effect can be obtained

by prepolarizing the material. The layer is therefore preferably prepolarized electrically, for example, by providing it with a conductive layer on either side by vapour deposition, heating the layer to above its Curie temperature, applying an electric voltage difference between the two conductive layers, and cooling the layer while said voltage difference is applied. The conductive layers may then be removed, for example by etching, and the side of the layer at which reflection of the light from the source is to take place may be polished and given a mirror finish if desired.

The electrostrictive or piezo-electric layer, sheet or plate in the device may be a self-supporting comparatively thick sheet or plate or a comparatively thin layer on a metal support which is substantially non-deformable. If the latter is the case the electrostrictive or piezo-electric material may cover the metal support entirely and have a substantially constant thickness everywhere. As an alternative, in order to increase the sensitivity of the layer, it may consist of a large number of self-supporting pillars, the deformation of the layer becoming manifest as a change in the height of the pillars. The pillars may extend down to the metal support or they may end at a continuous layer of the electrostrictive or piezo-electric material. The provision of such pillars enables the sensitivity of the device to be increased because a local variation of the height of a pillar as a result of an applied charge can be made independent of the variation or lack of variation of the height of the surrounding pillars.

If the layer is not pre-polarized or is pre-polarized in only one direction, a uniform deformation of the layer will occur over the whole of a large area thereof if the electron beam is incident on that area. In such a case the layer surface in the centre of the relevant area will be parallel to the surface of other parts of the layer on which no electrons have been incident so that the light reflected thereat does not change its direction and will not be transmitted by a grating (if present) in the direction of projection. A change of the direction of the reflected light will only occur at the transition between the region upon which electrons have been incident and the region upon which electrons have not been incident. In order to obtain a change in direction of light reflected from the whole of a large area upon which electrons have been incident, the layer is preferably not pre-polarized in one direction but provided with a pattern of pre-polarization at least on the side thereof at which the light is to be reflected. Preferably this pattern is a regularly alternating pattern, which has the advantage that, when the deposited charge is uniform over a large area, a regular undulation of the layer surface will occur which can be made to give a uniformly illuminated display. Particularly favourable results may be obtained when the length direction of elongate regions of the same pre-polarization is parallel to the direction of the lines of a grating (if present). With a comparatively thin electrostrictive layer, e.g. one about 0.2 mm thick, a pattern of conductors may be provided on either side thereof, this pattern being such that, when suitable voltage differences are applied thereto, regions are formed across the layer which are pre-polarized alternately in opposite directions. With a self-supporting comparatively thick plate, however, pre-polarization is difficult to achieve throughout the thickness thereof. Pre-polarization may then be provided only at one surface thereof by providing a pattern of conductors thereat in such manner that, when a voltage difference is applied between them, regions are formed at the surface of the plate which are alternately pre-polarized in opposite directions.

In order that the invention may be readily carried into effect, a few embodiments thereof will now be described in greater detail, by way of example, with reference to the accompanying diagrammatic drawing, in which:

Figure 1 is a sectional view of a part of a device for displaying pictures by projection;

Figure 2 is a sectional view of an electrostrictive plate;

Figure 3 is a sectional view of another electrostrictive plate;

Figure 4 is a sectional view of another electrostrictive plate;

Figure 5 is a plan view of a pattern of conductors which can be provided during the manufacture of a piezo-electric plate; and

Figures 6 and 7 are sectional views of other piezo-electric plates during manufacture.

In Figure 1 a cathode-ray tube 1 has a window 2, an electron gun 4 in a neck 3, and a plate 5 of electrostrictive or piezo-electric material. The display of Figure 1 also includes a specular grating 6 which forms a schlieren optical system and a number of lenses which are not shown. During operation of the device light 7 originating from a light source (not shown) is reflected by the grating 6 and the reflected light 8 enters the tube through the window 2. The light is in the form of a parallel beam in the tube and is reflected by the plate 5. If no electrons from the electron gun 4 are incident on the plate 5, the surface of the plate 5 is smooth and the light is reflected back along the same path. Thus no light is passed by the grating 6 in the direction of projection 9 and there is no display. When a charge is locally deposited on the plate 5 by means of an electron beam originating from the electron gun 4, the light reflected at that region is reflected at a different angle and is passed by the grating 6 in the direction of projection 9. A picture can thus be formed which is projected in the direction 9. Possible constructions of the plate 5 of electrostrictive

or piezo-electric material will be described with reference to Figures 2 to 7.

Figure 2 is a sectional view of an electrostrictive plate 11 constructed from a polycrystalline polished plate 12 of $BaTiO_3$, 0.2 mm thick, on a metal support 13 which serves as an electric current. The support may have dimensions of 6 cm × 9 cm.

Figure 3 is a sectional view of an electrostrictive plate 14 of polished sintered polycrystalline $PbZr_{0.5}Ti_{0.5}O_3$ having dimensions of 6 cm × 9 cm × 2.5 mm thick. A thin conductive layer 15 is present on its lower surface to serve as an electric contact.

Figure 4 is a sectional view of an electrostrictive plate 16 comprising a large number of self-supporting pillars 17 having dimensions of 0.2 mm × 0.2 mm present on a metal support 18. The pillars and a layer immediately beneath them consist of $BaTiO_3$. The height of the pillars, which have polished tops, is 0.2 mm. Such a construction can give improved sensitivity.

Figure 5 is a plan view of a pattern of conductors by means of which a piezo-electric plate may be pre-polarized. The pattern consists of conductors 19 and 20, the teeth of which may have a width of 0.1 mm. The distance between the conductors may be 0.1 mm. During scanning of the electrostrictive plate by the electron beam in the tube 1 of Figure 1 it is arranged that the frame scan direction is not parallel to the direction in which the resulting elongate regions thereof having the same pre-polarization extend, but is preferably at right angles thereto. Said direction in which said regions extend is preferably parallel to the direction of the lines of the grating 6.

Figure 6 is a sectional view of a thin piezo-electric sheet or plate 21 during its manufacture, namely when conductors similar to 19 and 20 of Figure 5 are still present on the plate. A pattern of aluminium conductors 22, 23 and 24, 25 having the same configuration as is shown in Figure 5 is provided by vapour deposition on both sides of a plate 21 of sintered $BaTiO_3$, 0.2 mm thick. The conductor 22 is situated opposite to the conductor 24 and the conductor 23 is situated opposite to the conductor 25. A voltage difference of 2000 volts is applied between the conductors 22 and 24 and between the conductors 23 and 25. This voltage is applied in the opposite sense on the two sides, this being signified in the Figure by + and −, the plate being simultaneously heated to above its Curie temperature. After cooling to below the Curie temperature a regularly alternating pattern of pre-polarized regions is thus obtained across the plate 21, this pattern remaining after the aluminium conductors 22, 23, 24 and 25 have been etched away and the surface at which the light will be reflected has been polished.

Figure 7 is a sectional view of a self-supporting comparatively thick piezo-electric plate 26 during its manufacture, namely when conductors similar to 19 and 20 in Figure 5 are still present on the plate. The plate may consist of sintered $BaTiO_3$, 2.5 mm thick, and a pattern of aluminium conductors 27 and 28 in the configuration shown in Figure 5 is provided on one side by vapour deposition. During manufacture a voltage difference of 2000 volts is applied between the conductors 27 and 28 as is denoted in the Figure by + and −. As a result a regularly alternating pattern of pre-polarization is obtained at the surface of the plate 26, which pattern remains after the aluminium conductors 27 and 28 have been etched away and the surface has been polished.

WHAT WE CLAIM IS:—

1. A projection display device comprising a cathode-ray tube containing an electron gun and a layer, sheet or plate of electrostrictive or piezo-electric material which is locally deformable under the influence of an electron beam from said gun, the device also including a light source for directing light to be reflected at said layer, sheet or plate.

2. A device as claimed in Claim 1, wherein said layer, sheet or plate is electrically pre-polarized.

3. A device as claimed in Claim 2, wherein the pre-polarization is in the form of a pattern at least on the side of the layer, sheet or plate at which said reflection is to occur.

4. A device as claimed in Claim 3, wherein said pattern of pre-polarization is a regularly alternating pattern.

5. A device as claimed in any preceding Claim, including a schlieren optical system in a path for light from said source which includes a reflection at said layer, sheet or plate.

6. A projection display device substantially as herein described, with reference to Figure 1 of the accompanying drawing, or to said Figure 1 as modified by any of Figures 2 to 7 of said drawing.

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1369241 COMPLETE SPECIFICATION

1 SHEET *This drawing is a reproduction of the Original on a reduced scale*

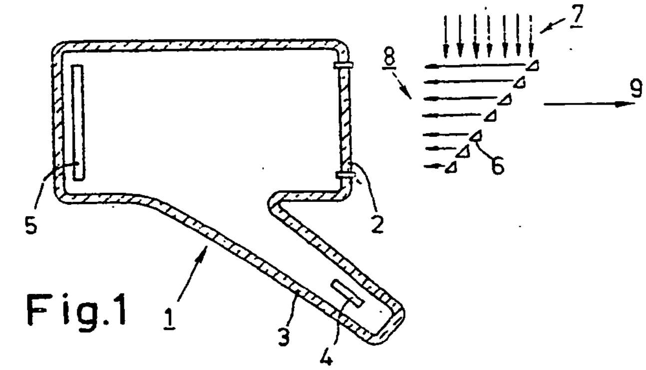


Fig.1

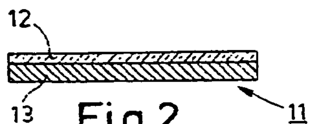


Fig.2

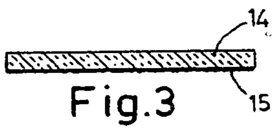


Fig.3

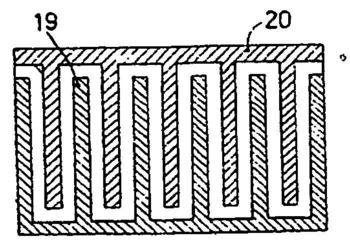


Fig.5

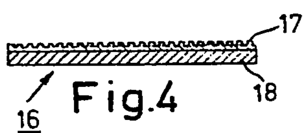


Fig.4

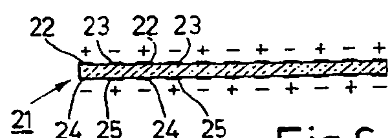


Fig.6

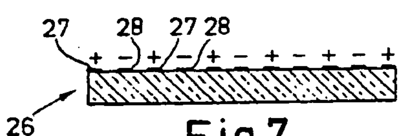


Fig.7